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ESTIMATION OF BIOMASS OF HORSE MACKEREL (*Trachurus trachurus* L.) IN NORTHERN-SPAIN (NORTHERN IXa AND VIIIc) USING THE DAILY EGG PRODUCTION METHOD.

by

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ABSTRACT

In order to estimate the spawning stock biomass of horse mackerel in the North Atlantic Spanish waters, a series of egg and adult cruises were carried out by IEO (Instituto Español de Oceanografía) and AZTI-SIO (Instituto de Investigación y Tecnología para la Oceanografía, Pesca y Alimentación).

The survey was carried out from 23 April to 25 May 1992. A total of 627 plankton samples and 37 adults samples were collected.

A total daily egg production of 3.3×10^{12} egg (SE = 7.26×10^{11}, CV = 0.22) was estimated for the whole area sampled (ICES Division VIIIc and subdivision northern IXa north). The estimate of horse mackerel spawning biomass ranged from 486,549 tons (CV = 0.34, when using adult parameter estimates exclusively from the Spanish survey, down to 368,814 tn (C = 0.32), when alternatively using an estimate of relative batch fecundity from the southern region of horse mackerel western stock.

INTRODUCTION

Horse mackerel is a target species of some commercial fleets in Northeast Atlantic waters. Total catches in the ICES area was were

estimated in 437.000 tons in 1992, including 28,000 tons fished by the Spanish fleet along the Cantabrian Sea and Galician Shelf (Division VIIIc and subdivision IXa north).

Following a recommendation of the ICES "Working Group on the Assessment of the stocks of Sardine, Horse mackerel and Anchovy" (Anon., 1990a), a survey aimed to a fishery independent assessment of the southern horse mackerel was prepared. It was developed according to plans agreed at he planning 'Workshop of Horse mackerel and Mackerel egg production' held at Ijmuindem in January 1991. Spain and Portugal agreed to carry out horse mackerel egg and adult cruises in Divisions VIIIc and IXa North. (Anon 1991).

For the time being the biomass of the Southern Horse mackerel have been evaluated by analitycal assessment (VPA) tuned with several fleets (Anon., 1993b). Up to date, fishery independent assessment of the European horse mackerel was only available for the western stock (Anon, 1987; Eaton 1989; Anon 1990b). This work is the first attempt to perform such an evaluation on the southern horse mackerel. This paper presents the results obtained from the survey carried out in spring 1992 by Spain in Division VIIIc and Subdivision IXa north.

MATERIAL AND METHODS

TABLE I gives main details on the survey arrangement. Different cruises aimed to collect egg and adult samples were performed during the period from 22 April to 25 May.

During the egg survey R/V Investigador sampled Sub-division IXa north and division VIIIc , from the River Miño (41° 50'N 9° 06'W) Spanish-Portuguese border to the city of Santander (3° 30'W). In the offshore direction, sampling extended up to 44° 30'N latitude. A similar area was covered during the acoustic/trawl cruise on board the RV Cornide Saavedra. During this cruise, adult fishing was restricted to the area within the 1,000 m and 20 m isobaths. Egg and adult sampling up to the eastern border of Division VIIIc was covered during a later survey, on board the same vessel, which finished the work in that area on 25 th May.

Sampling Strategy

Egg sampling and processing

A total of 627 plankton samples were collected following a systematic central sampling scheme (Figure 1). Sampling stations were located along transects 15 miles apart and separated 3 miles from each other. In areas where horse mackerel eggs where scarce or absent, the distance between stations increased to 6 miles. In

high abundance areas, additional transects were performed midway between the main transects. Sampling stopped wherever more than two consecutive stations contained zero values. In order to do that, samples were visually analyzed under magnification immediately after fixation.

Egg samples were collected using a PAIROVET version of the CalVET net (Smith et al., 1985) deployed vertically. The net was retrieved from a maximum depth of 100 metres, or 5 meters above the bottom, to the surface at an approximate speed of 1 m/sec. Volume filtered was calculated using calibrated flowmeters (GO 2030).

Whole samples were sorted for all fish eggs and the horse mackerel eggs were counted and staged following the criteria of Pope and Walker (1897).

Adult sampling and processing

Sampling intensity for adults was intended to be proportional to fish abundance (Judgement sampling, Picquelle & Stauffer, 1985). Echosounder detections and egg abundances were used as indicators of horse mackerel abundance. Trawling for horse mackerel was carried out wherever concentrations of horse mackerel were found. Fishing operations were carried out with a pelagic trawl with a vertical opening of 22 m.

Processing of adult samples followed the recommendations of the "Manual of the DEPM, 1992" (Anon. 1993a). This sampling procedure was even followed, when the trawl hauls id not contain the minimum number (30) of fish required. From each station, haul characteristics, sea surface temperature, catch, sample weight, fish length, fish weight, sex and visual maturity key was applied (cf "Manual" in Anon. 1993a). Otoliths were extracted for ageing purposes at the laboratory.

For histological study, 400 ovaries from the first 30 mature females of each haul were preserved in 4% formaldehyde buffered with 0.1 M sodium phosphate, dehydrated in alcohol and embedded in paraffin was. Sections were cut at 3 μm and stained with haematoxyling and eosin. The histological slices of 400 ovaries were examined and the presence or absence of the main oocyte maturity stages associated with spawning were recorded (ie migratory nucleus stage (MNS), hydrated oocyte stage (HOS) and early and late post-ovulatory follicles stages (early- and late-POFs). The presence or absence or all other oocyte maturity stages (including atretic oocyte) was also noted for each individual ovary sample. An adaptation of the stereological method was also applied for counting the number of oocytes of each stage in each slide.

For batch fecundity estimation, an adaptation of the stereological method was adopted (cf.'Manual' in Anon. 1993 a). The gravimetric method was not used . During the survey 22 hydrated ovaries were collected and most of them were processed for histological study

before counting of hydrated oocytes. Nine gonads were in bad condition and it was impossible to measure the volume accurately. As a result only 13 gonads were used for batch fecundity estimation.

data processing

The spawning stock biomass of horse mackerel is estimated according to the Daily Egg Production Model (DEPM, PARKER, 1980):

$$B = \frac{P}{DF} = kA \frac{P_0 W}{R F S}$$

where,

B = spawning stock biomass in tons,

P = total daily egg production in the sampled area. ($P = A P_0$)
A = survey area in sampling units,
P_0= daily egg production per surface unit in the sampled area,
DF= daily specific fecundity. ($DF = ((k R F S) / W)$).
k = conversion factor from grams to metric tons,
W = average weight of mature females,
R = proportion of mature females by weight,
F = batch fecundity,
S = fraction of mature females spawning per day.

Using the delta method, an estimate of an approximate variance for the biomass estimate is also provided (Picquelle & Stauffer, 1985).

egg data

The following calculation was for the conversion of eggs counted in the sample to eggs per m²:

$$\text{Eggs per m}^2 = \frac{\text{Depth} * \text{Eggs-counted}}{\text{Flowm-rev.} * \pi * (\text{Apert.}/2)^2 * \text{Flowm-calibr.} * \text{Efficiency-f}}$$

where:

Depth	=	depth of the plankton sampler (m)
Eggs-counted	=	number of eggs counted in the subsample
Flowm-rev.	=	number of flowmeter revolutions
Apert.	=	diameter of mouth opening of the sampler (m)
Flowm-calibr.	=	number of flowmeter revolutions per meter towed obtained from calibrations (m/rev)
Efficiency-f	=	efficiency factor of the plankton sampler

Numbers of stage I eggs per m² were then raised to numbers produced per m² per day using the development equation given by Pipe and Walker (1987) for horse mackerel. The series of Stage I egg

production per m^2 was then processed to get total daily production of horse mackerel eggs following standard procedures of the International mackerel/horse mackerel egg survey (Anon., 1993a). It was assumed a filtration efficiency of 100% for the CALVet net.

Variance of the total daily egg production was calculated following the procedure of Pope and Woolner (1984), which allows estimation of the variance of the total production in a rectangle when only one sample has been collected within it. The use of the CalVET net allows for the collection of more than one sample within each rectangle. For the 1992 egg survey, a mean of 13 samples was collected per rectangle.

adult data processing

For spawning fraction estimation, histological slides of 400 ovaries from 12 hauls were examined and scored according to criteria established in the "Manual of the DEPM, 1992 (cf Appendix in Anon., 1993). Ovaries from immature fish, checked by means of histological examination, were not included in the spawning fraction estimation, because only adult mature females should be sampled. As it was accorded in the 1992 Daily Egg Production Method, the estimate of the fraction of females spawning was made from the proportion of females within a haul having migratory nucleus stage (MNS) oocytes in their ovaries. For each haul the proportion of MNS -and the other two main maturity stages- was weighted to the standard number of ovaries by haul (30 ovaries). No problems were found in the identification and counting of oocytes with migratory nucleus stage (MNS).

For batch fecundity estimation, the number of oocytes in the ovary was determined applying the theorem of de Hoff and Rhines (1961).

$$\mathbf{N_v = N_A / D}$$

where:

N_v= is the number of oocyte per unit volume

N_A= is the number of oocyte within a unit area of section, the area density.

D = the diameter of the oocyte

This calculation is based on the principle that the section samples a volume of thickness equal to the diameter of the oocyte. The total number of oocyte in the ovary **N** is then:

$$\mathbf{N = N_v * V}$$

where:

V = the ovary volume

In the area of a fixed rectangle of 5.5 x 4.5 mm that corresponds to at least a third of the whole slide area, all the hydrated oocyte were counted by a binocular microscope, avoiding bias by the use of the "forbidden line" rule (Gundersen, 1977). In some cases two or three replicas of this count were obtained and the arithmetic mean value was used. The diameter of the hydrated oocyte in the slides was estimated to be 0.9 mm. The unit sample volume was calculated as 5.5 x 4.5 x 0.9 = 22.275 mm^3. Consequently, the number of hyaline oocytes estimated for the whole ovary is :

$$N = (N_A / 22.275) * V$$

RESULTS

egg production

A total of 48 standard ICES rectangles were sampled, where 40 were positive for horse mackerel eggs. Figure 2 shows the distribution and number of egg samples per rectangle.

A total daily egg production of 3.3 x 10^{12} eggs (SE = 7.26 x 10^{11}, C = 0.22) was estimated for the whole area sampled (VIIIc and IXa north).

The geographic distribution by rectangle of total production of horse mackerel eggs is shown in Figure 3. Two regions of high densities can be observed; one off La Coruña (west of 8°30' W and north of 43° N) which represents 25 % of the egg production in the whole area and another one in mid eastern Cantabrian waters, spreading along the shelf edge from 3° 30'W to 5° 30' W and onshore from 2° 30' W to 3° 30' W. In the southern region Galicia (IXa north), a marked decrease in horse mackerel eggs was observed, reaching zero values to south of 42 °N. In Division VIIIc, high egg abundances were not restricted to the shelf break. Up to 415 eggs per m^2 were observed in coastal waters in the area, with several rectangles both near the shelf and in the coast producing over 100 egg per m^2.

adult parameters

A total of 37 hauls were carried out of which 12 were positive for horse mackerel (Figure 4). Non positive hauls occurred for horse mackerel in sub-division IXa north. Trawling was attempted throughout the dial cycle, but unfortunately it was not possible to obtain samples at 0300-0600 hrs and 1800-2100 hrs UTC (Figure 5).

Tables 2 and 3 show the length and age distributions of horse mackerel catches in the whole area sampled. The ages are distributed between 5 and 11 years old except for the rectangle 16E4 in front of Santander (sub-division VIIIc east), where older fish and high egg abundance occurred. Juveniles were only found in the most eastern part of the Cantabrian Sea (16E7). The 1982 year

class appeares to be predominant in adult fish.(Abaunza ,P and Carrera 1993).

A total amount of 400 ovaries were processed histologically and examined . The number of female horse mackerel with the main three maturity stages in their ovaries for all the trawl samples together considered were so :

Migr.nucleus stage (MNS)	Hydr.oocyte stage (HOS)	Early POFs
36	21	9

In Figure 6 the prevalence (in percentage) of MNS, hydrated oocytes and early POFs in three hour time periods are presented . Peak percentage of fish with POFs in the ovaries was at 06:00-09:00 hours but decreased to zero value at 15:00-18:00 hours indicating release of eggs a that time.

Assuming that the MNS lasts 24 hours, the prevalence of this stage can be used as representative of the spawning fraction, v.gr. the number of females spawning per day (Anon., 1993). For all hauls together the mean prevalence of MNS, weighted to the standard number of ovaries by haul (30 ovaries) is presented in the following text table:

Spawning fraction (Migr. nucleus stage) (S_{mns})	SE	C
0.0847	0.02	0.2255

According to this the time interval between batches of eggs is indicated to be 11.8 days (batch interval (T_b)= $1/S_{mns}$).

Batch fecundity per gram F_{bw} was estimated from a regression of batch size on fish weight. The regression was forced through the origin (Figure 7). The value of F_{bw} is presented in the following text table:

Area	F_{bw} (eggs/g)	SE	n
Division VIIIc	160.2	17.89	13

Spawning biomass estimates

According to the results in the previous sections two estimates of horse mackerel spawning biomass can be obtained. Using the adult parameter estimates exclusively from the Spanish survey a spawning biomass of 486,549 tonnes was calculated (C = 0.34). However, in view of the rather small sample size and the unconventional estereological techniques used for the batch fecundity estimate an alternative approach was considered. Assuming the estimate of batch fecundity from the southern region of the western area (211.34 eggs per gram female, (Anon., 1993a). This approach gives a horse mackerel spawning biomass of 368,814 tonnes (C = 0.32). Table 4 shows the two spawning biomass estimates.

DISCUSSION

For assessment purposes the Northeast Atlantic Horse mackerel population is currently divided into three "stocks units": North Sea, Western and Southern Horse mackerel. The biological basis for the division into Western and Southern Horse mackerel stocks is not well established, but it is agreed in the more recent ICES Working Group that, for the time being, assessments would be made for these two "Stocks" separately (Anon.,1993b). The Southern Horse mackerel stock unit is confined to the geographical area that includes ICES Divisions VIII and IXa (Figure 1).

Egg survey area

The egg and adult surveys analyzed in the present work did not cover the entire geographical range of the Southern Horse mackerel but only the area off the Northern (Division VIII) and Northwestern Spanish coast (subdivision IXa). So any SOB estimate derived here should be considered as a fraction of the whole Southern Horse mackerel spawning "stock".

Horse mackerel eggs were still present at 44° 30′ in transacts along 7° 20′W and 6°W although scarcely. This means that most of the spawning stock distribution in Division VIII and sub-division IXa north was covered during the survey, therefore it is assumed that the SOB present in the area surveyed was not underestimated.

In the Southernmost part of the survey area (sub-division IXa north) two transects with no eggs were found, showing a gap of egg production in this area. Further data is not available on the extension of this egg production gap into the Portuguese coast (sub-divisions IXa central and south). In the Northeastern part (

sub-division VIII east), egg production still continued beyond the border into Division VIIIb (East of 2°N and North of 44°30'). This fact is a consistent pattern of horse mackerel egg distribution in this sea area, and it evidences at least some degree of continuity between the Southern and Western stock units in the Southern Bay of Biscay(Franco et al., 1993).

Timing of egg production.

Egg cruises were performed from 23 April to 24 May which matches well with egg production peaks of this species in the area. Solá et al. (1990) analyzing the seasonality of horse mackerel spawning in this area gave a preferential temperature range from 12°-18°C and peak spawning through April, May and June. Lucio and Martin (1989) analyzing the monthly maturity stages and gonosomatic indices observed in commercial samples from sub-division VIII east and Divisions VIIIa and b in 1987 and 1988 found also that the peak spawning season corresponded to April, May and June in the same area.

Magnitude of egg production.

Data on egg production in waters off the Northeast and Northwest coast of Spain is available from 1988, 1990 and 1992 from egg cruises using similar methodology (Franco et al., 1993). 1992 is the year of highest egg in the series. It is three times higher than in 1988 and twice the egg production in 1990. Assuming that all the cruises were carried out at peak spawning in the area, those results indicates an important increase of egg production in the area. Whether this indicates an increase in spawning biomas or not we do not know, because it lacks information on adult parameters from 1988 and 1990.

Spawning faction

For this work with Southern horse mackerel, the Migratory Nucleus Stage (MNS) has been considered for determining the spawning fraction, as it was with Western horse mackerel ovaries, and not special problems were found in processing and analyzing the samples.

The percentage of Southern female horse mackerel with MNS in their ovaries, calculated as arithmetic means of all the trawl samples (8,47%), it is within the range of MNS values obtained for Western horse mackerel (2,9%) in the northern area, 9,7% in the central area, 4,9% in the southern area, and 6,1% for the total area) (Anon., 1993a).

The synchronous spawning of this species and the lack of samples at some times of the day could explain why few ovaries appeared in the hydrated stage or with early POFs. Motos (1993) analyzed the dial periodicity of the occurrence of the early stages of horse mackerel eggs in four annual series of observation between 10th May

and 13rd June in the spawning seasons from 1989 to 1992. Most new horse mackerel eggs appeared in plankton samples taken between 12:00 and 24.00 hours (GMT). Very few eggs occurred between 06:00 and 12:00 hours. The peak egg production was between 15:00 and 21:00 hours.

It must be recognized that same considerable uncertainties exist at the present time in the estimation of spawning fraction in horse mackerel by means of MNS - v.gr. exact duration of the Migratory Nucleus. Stage (24 hours or more or less), constancy of this stage during all hours of the day if its duration is 24 hours, etc.

Batch fecundity

The batch fecundity value (160 eggs per gramme female) estimated for Southern horse mackerel in the Spanish area resulted different from the Western horse mackerel value (209 eggs per gramme).A first and rapid explanation of this fact could be that Southern horse mackerel has an evident lower batch fecundity. But , the number of ovaries hydrated used for this purpose (only 13 ovaries resulted valid for the determination) is too low and almost all of the ovaries correspond to a very short total fish weight range (Figure 7) . By other hand , the Southern horse mackerel batch fecundity was determined using an application of histological techniques to histological preparations and the Western horse mackerel batch fecundity was calculated by means of the standard gravimetric method (Anon 1993 a). Nevertheless , as the high batch fecundity value obtained from a Southern large fish is comparable with the values obtained from similar size Western Horse mackerel , it might indicate that some of the ovaries used for batch fecundity were or incompletely hydrated or partially spent or with a part of hydrated oocytes missing during histological preparation proceeding. Perhaps also the same sampling scheme used (diel time , sea area , vertical opening of the gear ,...) was not the more appropriate for obtention of representative samples of females with hydrated ovaries .

Because of all these uncertanties , an alternative batch fecundity value has been considered for Southern Horse mackerel biomass estimate , i.e. 211.34 eggs per gramme female , that correspond to the Western horse mackerel batch fecundity from the southern region , i. e. between 46° 30′ N and 47° 30′ N. This batch fecundity value was choosen because of the consistency in the similarities in the length and age distribution of the samples and the proximity in the time of the fish surveys for Southern (Division VIIIc) and Western (southern region : Division VIIIa,b) horse mackerel.

Biomass estimates

Both spawning biomass estimates for Southern horse mackerel , using one or other relative bach fecundity value, ie. 486, 000 and 368,000 tons, take only in account the Southern horse mackerel in the Spanish waters.

As the non-spawning immature fish has been excluded in calculating the spawning fraction, the Southern horse mackerel estimated biomass refers only to fish in spawning condition and represents therefore the spawning biomass, as it was made with Western Horse mackerel (Anon., 1993a).

Similar assumptions for Southern an Western horse mackerel were taken in account for spawning biomass calculations (Anon., 1993a):

- Sex ratio was assumed to be as one female to one male (R = 0.5).

- The total Southern horse mackerel population in Spanish area was present in the area covered by the egge survey.

- Spent fish had not yet left the area covered by the trawl survey, both the egg and fish surveys having been carried out in the peak of spawning season.

- Fish were sampled over the whole water column.

- The fraction of spawning females as obtained from sampling on, the continental shelf is assumed to be the same for the off shelf area.

- The migratory nucleus stage (MNS) was assumed to last 24 hours.

The spawning biomass estimates for Southern horse mackerel in the Spanish area presented in this work must be considered as preliminary, due mainly to the uncertainties in estimating the spawning fraction (S) and the batch fecundity (F).

The analytical assessment (VPA) of the Southern Horse Mackerel stock , shows a range of the spawning biomass level estimated , wich varies from approx 200-350 thousand tonnes . The eeg survey estimates for 1992 , for the spawning stock biomass in the Spanish waters , have some limitations due to the uncertanties in the spawning fraction and batch fecundity , but achieved approximately the same range of 200-400 thousand tonnes (Anom 1993b).

REFERENCES

Abaunza, P. and Carrera, P. WD 1993. Acoustic survey Pelacus-0493. presented to the Mackerel Horse Mackerel Egg Production Work-shop. 1993

Anon. 1990a. Report of the Working Group on the Assessment of the Stocks of Sardine, Horse Mackerel and Anchovy. CM 1990/Assess: 24, 169pp.

Anon. 1990b. Report of the Mackerel/Horse Mackerel egg production Workshop. C.M. 1990/H:2.

Anon. 1991a. Report the Mackerel/Horse Mackerel Egg Production Workshop. ICES CM 1991/H:2, 43pp.

Anon. 1993a. Report of the Mackerel/Horse Mackerel egg production workshop. C,M. 1993/H:4.

Anon . 1993b. Report of the working Group on the assessment of the Mackerel, Horse Mackerel , Sardine and Anchovy. C.M.1993/Assess:

De Hoff, RT. and Rhines , F.N. 1961. Determination of the number of particles per unit volume from measuerments made in random plane sections. Tras. Am. Inst. Mineral Met. Eng., 221.975-981.

Eaton, D.R. 1989. Spawning-stock biomass of scad (Trachurus trachurus L.) to the west of the british Isles, as indicated by egg surveys. J. Cons. Int. Explor. Mer, 45.

Eltink, A. 1991. Batch fecundity and faction spawning of horse mackerel (Trachurus trachurus L.). Final Report of a Study contract submited to the Directorate-Genereal for Fisheries GXIV) of the Commission of the European Comunities.

Gundersen, HJ.G. 1977. Notes on the estimation of the numerical density of arbitrary profiles: the edge effect. J. Microsc., 111, 219-223.

Lago de Lanzos. A , Solá, A. Motos, L. and Franco, C. WD 1993. Daily egg production of horse mackerel in ICES Divisions VIIIc and IXa north in 1992.

Lucio, P. and Martín, I., 1989. Biological aspects of Horse Mackerel (Trachurus trachurus L. 1758) in the Bay of biscay in 1987 and 1988. ICES, Doc. C.M. 1989/H:28, 22 pp.

Motos, L. WD 1983. Diel periodicity of the occurrence of early egg stages of horse mackerel.

Picquelle & Stanffer, 1985. Parameter estimation of an egg production method of anchovy biomas assesment. In: Lasker, 1985: 7-16.

Pipe, R.K. and Wlalker, P. 1987. The effect of temperature on developement and hatching of scad, Trachurus trachurus L., Journal of Fish Biology, 31, 675-682.

Pope, J.G. and Woolner, L. 1984. An investigation of the precision of the 1983 western mackerel egg survey. ICES. C.M. 1984/H:70 13 pp.

Smith, P.E.., Flers, W. and Hewitt, R.M. 1985. The CalCOFI Vetical Egg Tow (CalVET). In: "An egg production method for estimating biomass of pelagic fish: application to the northern anchovy, Engraulix mordax". Ed. R. Lasker. Dep. Commer, NOAA Tech. Tep. NMFS 36, 37-32.

Solá, A. Motos, L. Franco, C and Lago de Lanzos ,A. 1990. Seasonal ocurrence of pelagic fish egg and larvae in the Cantabrian Sea (VIIIc and Galicia IXa), from 1987 to 1989 . ICES.CM. 1990/ H:26.

Vessel	cruise type	activity	gear	dates
CORNIDE DE SAAVEDRA	acoustic survey	adult sampling	pelagic trawl	22 April-12 May
	Egg/Adult survey	egg sampling adult fishing	CALVet net Pelagic trawl	15-25 May
INVESTIGADOR		egg sampling	CALVet net	23 April-9 May

TABLE 1: Details of the DEPM survey for the assessment of horse mackerel spawning stock biomass in VIIIc and IXa north.

Table 2 . Length distributions of southern horse mackerel by half ICES rectangle during the DEPM in 1992 (ordered from west to east). All hauls from RV "Cornide de Saavedra": hauls 409-429 from "Pelacus-92"survey and hauls 302-302 from "Bioman-92"survey.

Haul	409	411	413	414	416	417	419	425	426	429	302	303
Rectangle	16E1 E	16E2 W	16E3 W	16E3 W	16E4 W	16E4 E	16E4 E	16E6 E	16E7 E	16E6 E	15E7 E	16E7 E
Length												
11												
12												11
13												24
14												50
15												21
16												1
17												
18												
19												
20											1	
21												
22												
23												
24								12	2	7		
25		1		1	1			127	2	132	1	4
26		11		1	7		2	207	11	423	7	12
27	9	53		22	6	2	10	183	18	529	14	30
28	16	90	1	26	6	3	27	50	24	225	24	18
29	8	35	1	18	5	1	30	3	18	46	24	4
30	3	6	2	8			15		9		14	4
31				1			8	6	7		10	5
32	1					1	5		4		1	
33							1	3	3		1	
34						3	2				1	
35						3	3			7		
36						4	1		1		1	
37						1						
38						1	1					
39												
40												
41						1						
42												
Total	37	196	4	77	25	20	105	591	99	1369	99	184
Catch (Kg)	7,1	37,1	0,9	15	4,8	7	23,4	94,5	20,3	324,9	27,1	8,9
Mean length	28,2	27,8	29,2	28,1	27,2	33,3	29,3	26,3	28,4	26,7	28,6	12,9
Number/kg	5,2	5,3	4,4	5,1	5,2	2,9	4,5	6,3	4,9	4,2	3,7	20,7

Table 3. Age distributions of southern horse mackerel by half ICES rectangle during the DEPM in 1992 (ordered from west to east). All hauls from RV "Cornide de Saavedra": hauls 409-429 from "Pelacus-92"survey and hauls 302-302 from "Bioman-92"survey.

Haul	409	411	413	414	416	417	419	425	426	429	302	303
Rectangle	16E1 E	16E2 W	16E3 W	16E3 W	16E4 W	16E4 E	16E4 E	16E6 E	16E7 E	16E6 E	15E7 E	16E7 E
Age												
0												
1												14
2												
3												
4								1				
5	5	3		5	3			8	1	6	2	2
6	4	6	1	5	11	3	4	8	2	16	6	7
7	3	4		3	2		3	1	6	2	2	1
8	2		1	3	1			4		1	2	
9	4	3		5		2	3	2	4	1	1	1
10	13	10	2	8	3	8	16	4	15	2	10	5
11				1		1						
12						1	1					
13						2	1					
14												
15						1						
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
Total aged	31	26	4	29	20	18	28	28	28	28	23	30
Catch (kg)	6.2	88.3	1	25	5.1	11.1	33.4	60.3	27.8	117.5	27.1	8.9
Mean age	8.1	7.9	8.5	8.1	6.6	10	9.1	6.7	8.7	6.3	8	4.4

DEPM Parameters	1*	2**
Daily Egg Production	$3.3 * 10^{12}$ (0.22)	$3.3 * 10^{12}$ (0.22)
Female weight	193.29 (0.04)	193.29 (0.04)
Sex ratio	0.5	0.5
Relative batch fecundity	**160.19** (0.12)	**211.34** (0.02)
Spawning fraction	0.0847 (0.23)	0.0847 (0.23)
Spawning biomass	**486,549** (0.34)	**368,814** (0.31)

Coefficient of Variation in brackets
* F_{bw} estimate using stereology on ovaries collected in the survey area.

** F_{bw} estimate taken from the southern region of the western area.

TABLE 4: Egg production and biological parameters for the DEPM of horse mackerel in the Spanish area. Two spawning biomasses are obtained depending on which batch fecundity estimate is used.

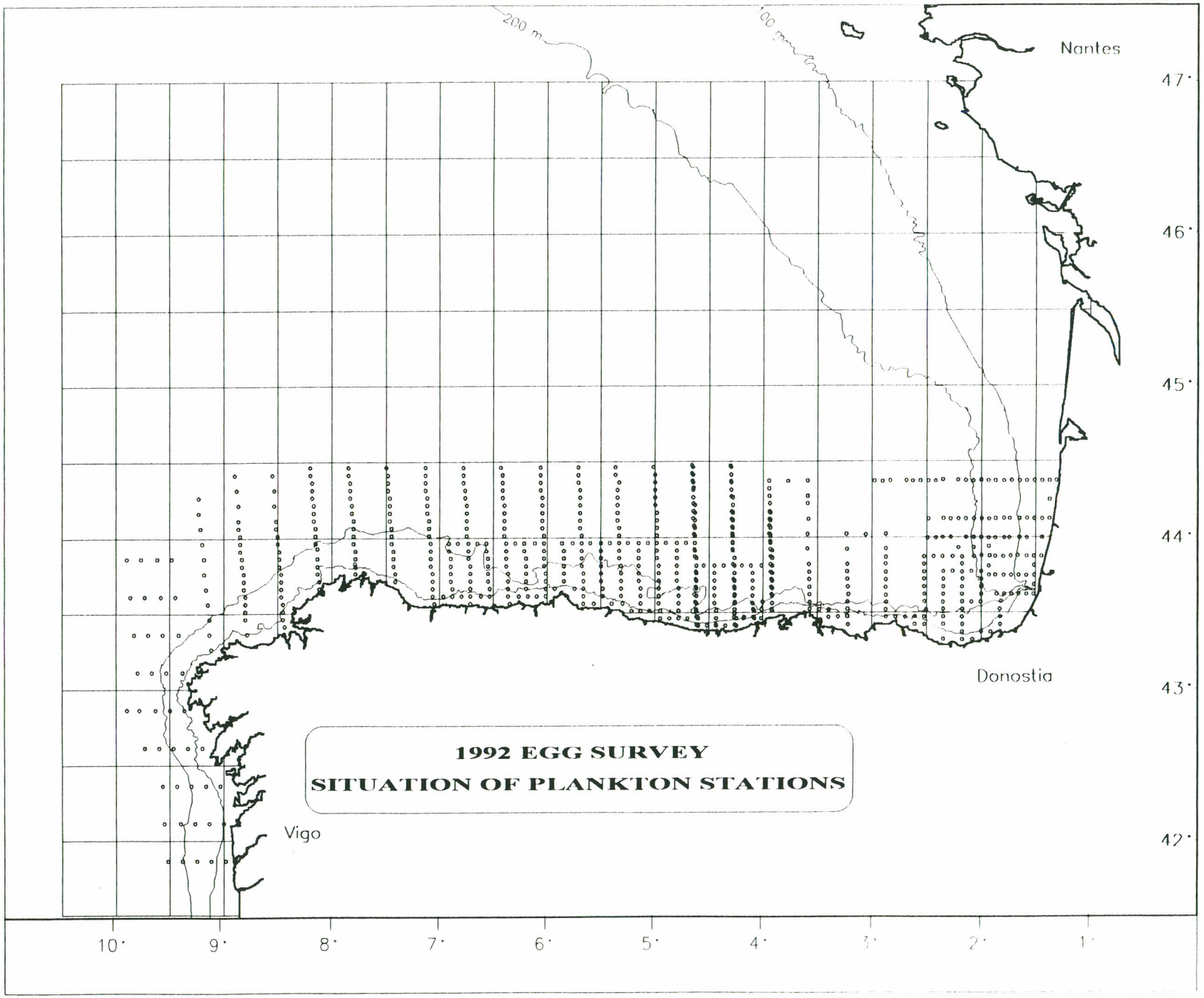
200 m
100 m
Nantes
Donostia
Vigo
1992 EGG SURVEY
SITUATION OF PLANKTON STATIONS
47°
46°
45°
44°
43°
42°
10°
9°
8°
7°
6°
5°
4°
3°
2°
1°

Figure 1

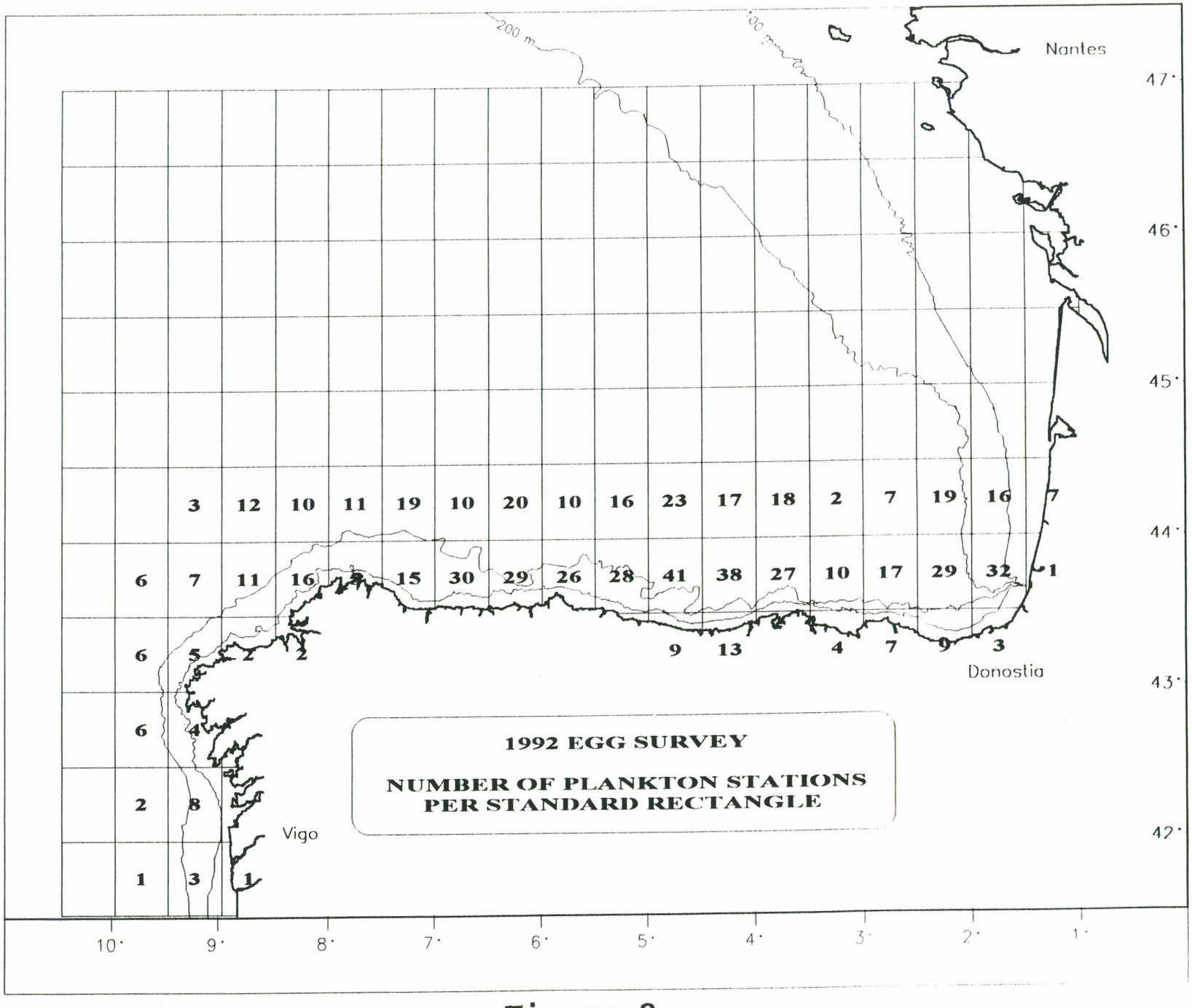
200 m
100 m
Nantes
Donostia
Vigo
47°
46°
45°
44°
43°
42°
10°
9°
8°
7°
6°
5°
4°
3°
2°
1°
3 12 10 11 19 10 20 10 16 23 17 18 2 7 19 16 7
6 7 11 16 15 30 29 26 28 41 38 27 10 17 29 32 1
6 5 2 2 9 13 4 7 9 3
6 4
2 8
1 3 1
1992 EGG SURVEY
NUMBER OF PLANKTON STATIONS
PER STANDARD RECTANGLE

Figure 2

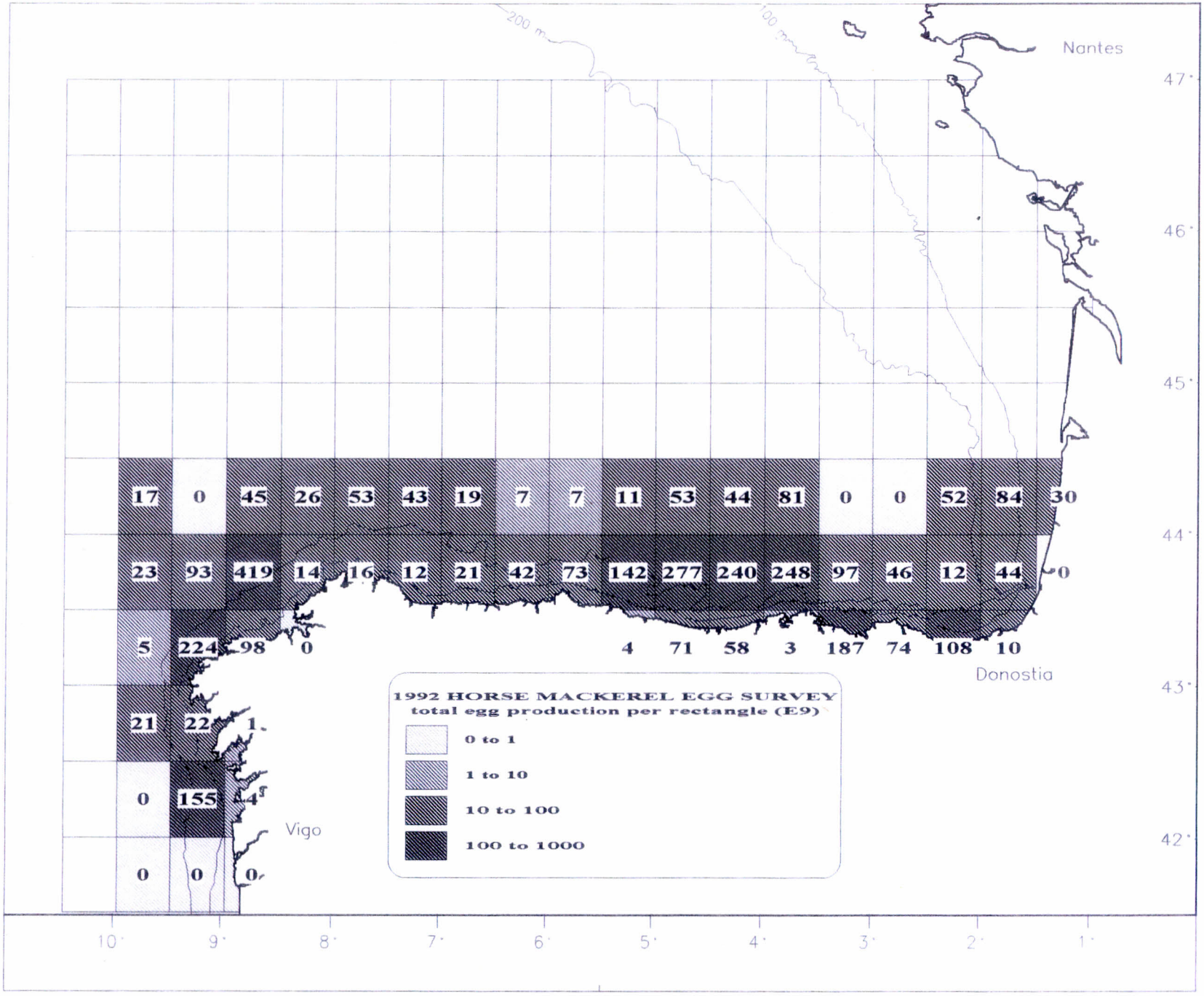
200 m
100 m
Nantes
Donostia
Vigo
47°
46°
45°
44°
43°
42°
10°
9°
8°
7°
6°
5°
4°
3°
2°
1°
17 0 45 26 53 43 19 7 7 11 53 44 81 0 0 52 84 30
23 93 419 14 16 12 21 42 73 142 277 240 248 97 46 12 44 0
5 224 98 0 4 71 58 3 187 74 108 10
21 22 1
0 155 4
0 0 0
1992 HORSE MACKEREL EGG SURVEY
total egg production per rectangle (E9)
0 to 1
1 to 10
10 to 100
100 to 1000

Figure 3

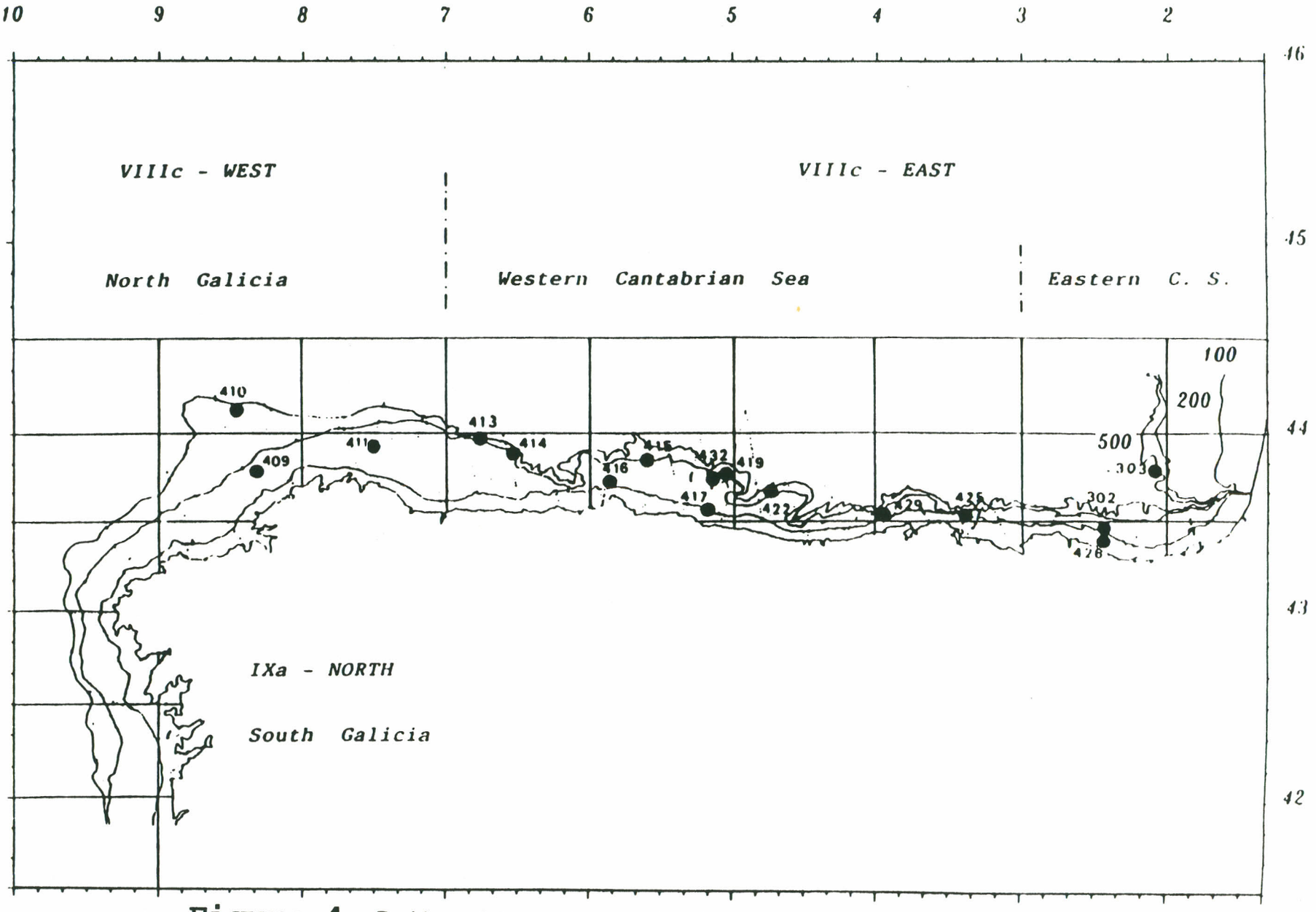

Figure 4. Positions of the positive samples of horse mackerel in Division VIIIc.

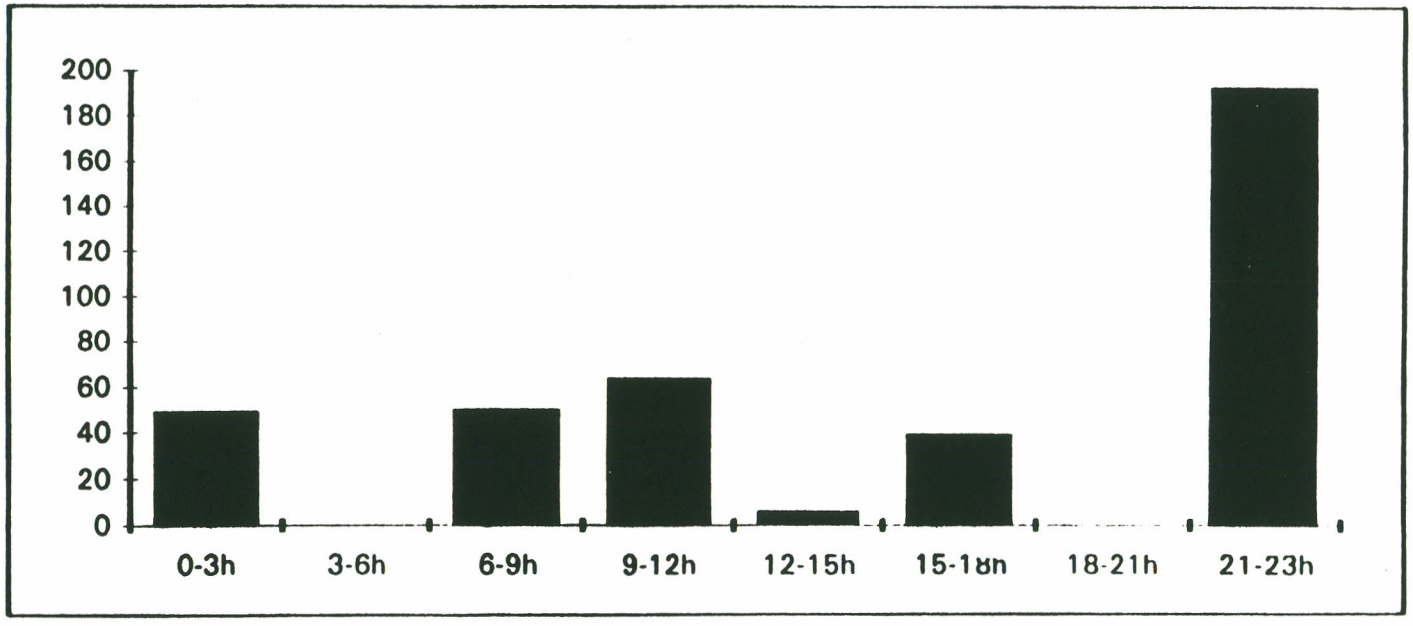

Figure 5. The number of horse mackerel taken by 3 hour time intervals in Division VIIIc.

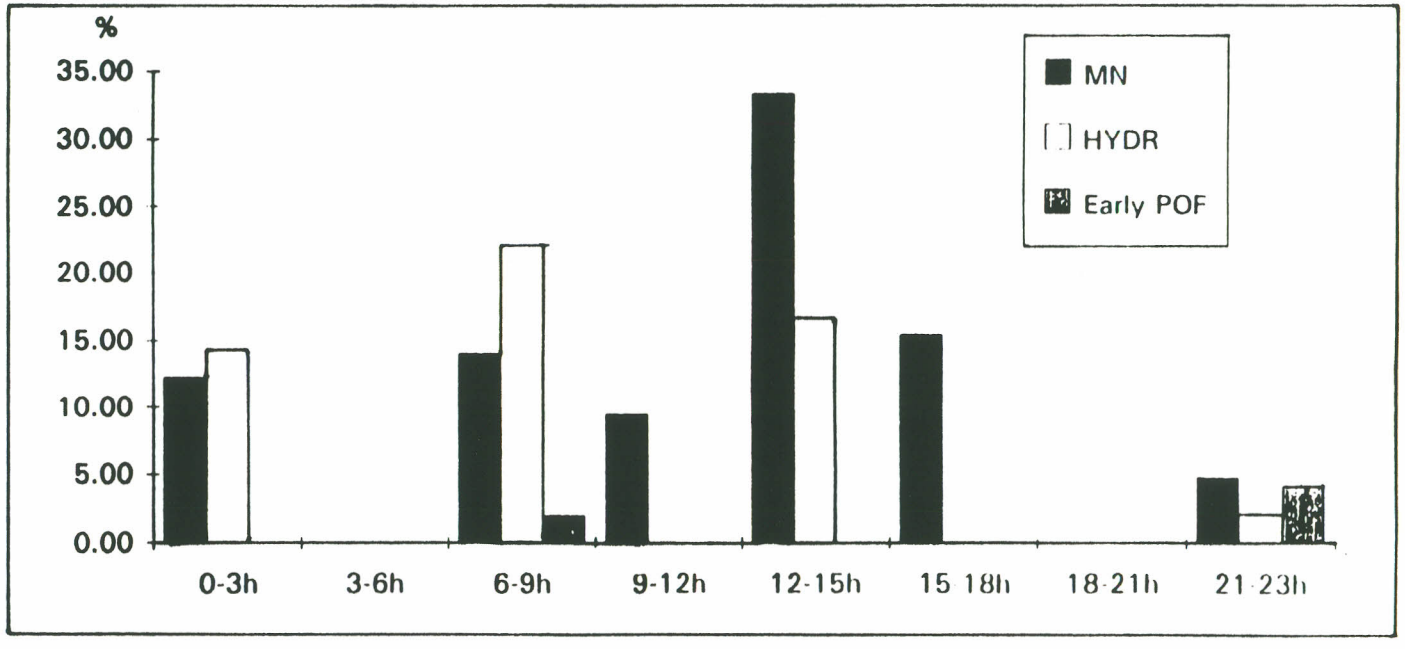

Figure 6. The percentage of southern horse mackerel ovaries with migratory nucleus and hydrated oocytes and with early post-ovulatory follicles per 3 hour time periods from the DEPM 1992 in Division VIIIc and IXa.

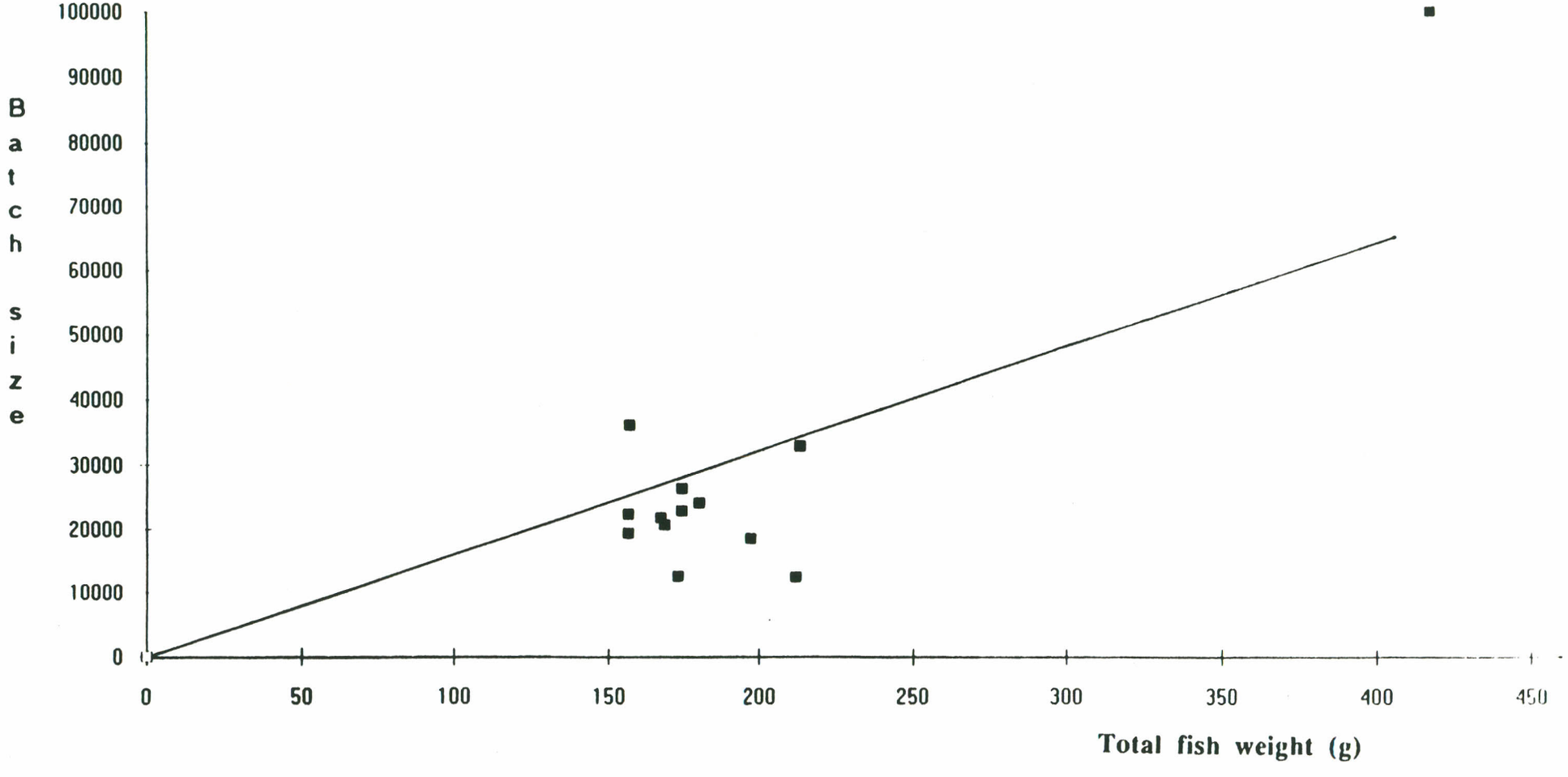

Figure 7. The batch fecundity-weight relationship of 160 eggs per gramme female horse mackerel in the Spanish area of Division VIIIc in 1992.